1-1-1996

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96-001

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MANAGING A NETWORK OF PLANTS WITHIN MULTINATIONAL FIRMS

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2/26/96

* The research was conducted with financial support from the Technology Transfer Research Initiative at the Krannert School of Management. The data for this study came from a survey conducted by Brian Talbot and Aneel Karnani and we are grateful to them for the use of the survey results. We would also like to thank Anil Khurana, Clayton Hubner, and Joan Penner-Hahn who worked on the survey instrument and helped to create the database. Arnoud De Meyer gave us useful comments on an earlier draft when it was presented at the Strategic Management Society in October, 1995, Mexico City. Rao Kadiyala, Maqbool Dada, and Pat McCarthy gave us helpful comments concerning the methodology.

MANAGING A GLOBAL NETWORK OF PLANTS

Abstract

The paper examines whether plants with different roles in a multinational network of plants use different management systems to coordinate production and technical decisions. The paper first tests and supports the Ferdows(1989) technology distinctions concerning plant roles. Following Ferdows (1989), it empirically examines the proposition that the degree of managerial autonomy varies according to strategic role of the plant. Our findings suggest that different plant roles require different management systems and different levels of responsibility for decisions. Further, it shows which systems need to be differentiated if plants with different roles are combined within the same business unit.

A company can manage a group of plants as an international network to learn more about technology, customers, products or processes than it would learn in one location. It may also gain advantages in cost or flexibility of managing a group of plants as a network that it would not achieve if these plants were managed as stand alone entities (Schmenner, 1979; 1982). One advantage of optimizing a system of plants is that plants can specialize in activities. Along with that specialization, plants develop roles within the system and have distinct management systems in place to then transfer the benefits of the specialization back to the other plants in the network. Thus there should be a "fit" between particular types of management systems which provide integration for particular specialized plant roles. This paper investigates whether there are differences in management systems for plants with different roles in a network.

We first test whether distinctions based on technical activities at the plant site as well as access to local technology are important distinctions to make for understanding different plant roles. These distinctions go considerably beyond the simple view that plants might differ based on access to inputs or markets alone. We show that these distinctions are associated with different management systems and that the new distinctions are strongly associated with corresponding management systems.

We also explore the nature of the fit between plant roles and management systems. Given that systems support strategic roles, these systems may be compromised, or plants may be managed inappropriately, if managers use a common management system throughout the business unit to manage plants with different strategic roles. Alternatively, this suggests that if managers know which management systems need to be different for different plant roles, they can differentiate the management systems within their network to match the roles of plants. We use the empirical findings to identify the specific conflicts in management systems that occur when different plant types operate within the same network. These conflicts will indicate to managers which types of management systems need to be differentiated to appropriately manage networks of plants which include plants with different strategic roles.

While others have argued for differentiated fit in multinational firms, these arguments have been for the headquarters-subsidiary relationship (Bartlett and Ghoshal, 1989; Gupta and Govindarajan, 1986; Gupta and Govindarajan, 1991; Ghoshal and Nohria, 1989; Nohria and Ghoshal, 1994). The suggestion here is that while "strategic fit" may be important in the headquarters-subsidiary relationship, this is brought about through management systems that must be in place at the plant, and in the plant-business unit relationship. Through an empirical assessment of the presence of fit between different management systems and plant types in multinational firms, we seek to extend the literature on managing and controlling multinational firms.

Theory Development

Most of what we know about differentiated fit in multinational firms follows research on managing a network of business units within a multinational firm. This perspective emphasizes that business units within multinational firms differ in terms of their demands for global integration or local responsiveness. The focus is on how the linkages between business unit managers and corporate headquarters differ according to the strategic roles of the business units in the network. We are interested in an analysis at a lower level of the organization.

There are many conceptual articles concerning the challenges of coordinating a plant network and the ways in which these challenges may differ in an international context (Ferdows, 1989; Flaherty, 1986; Oliff, Arpan, and Dubois, 1989). Some of these constructs are derived primarily in terms of material flows (Flaherty, 1986), while others describe the intended role of the plant. While different frameworks identify particular issues of interest to managers of international networks, what is missing is an empirical assessment of the implications of a framework for the management of a plant network. In particular, are plants with different roles in such a framework managed differently? If not, it may be that common systems are used for different plant roles, or that business units do not have plants with different roles. This might be the case if there were no benefits of specializing plant roles or if the costs of integrating specialized plant roles exceeded the benefits of specialization. In this case plants in a business unit may not be managed as part of a network and plants could be seen as simply extensions of the strategy of the business unit which might be "multidomestic" or "global" (Bartlett and Ghoshal, 1989).

What are the management systems that are necessary for different plant roles within the network? We want to investigate a number of questions concerning management of these plants. First, are there some decisions which headquarters wants to control regardless of the type of plant? Second, what is the degree of investment in management at the plant and do plants with more management depth have greater autonomy over some production decisions than other plants? For example, are particular decisions controlled by the plant, the plant in combination with other plants, the plant in combination with headquarters, or are they purely in the domain of headquarters? Third, how does autonomy over different types of production decisions vary for plants that are located for access to inputs as opposed to access to markets? Finally, what is the degree of autonomy over technical production decisions for plants with technical expertise at the plant site?

To examine how management systems might differ within a network we need to have a clear definition of what different plant roles might be. We empirically test whether there is a "fit" between specific management systems and strategic plant roles in the manner suggested by Ferdows (1989).

Ferdows (1989) developed a framework to differentiate a set of generic strategic roles for factories in a firm's international manufacturing network. These roles are defined in terms of the primary reason for establishment of the factory and the extent of technical activities at the site. Reason for the site is divided into three categories: 1) Access to low cost production input factors, 2) Use of local technological resources and 3) Proximity to market. Extent of technical activities is classified as being either "high" or "low" (See Table 1).

Insert Table 1 about here

Hypotheses

Plant Roles Defined by Technology at the Site and Access to Local Technology. Ferdows' framework differs from other models of factory types in its emphasis on the role of Technology at the Plant Site and Access to Local Technology in defining plant roles. These distinctions highlight differences in the management of technology transfer between the plant and its business unit. The distinction between plants that need "access to local markets" and other plants is well established in international management literature (Prahalad and Doz, 1987). Therefore, a strong alternative typology to that of Ferdows (1989) would be that one should not make a distinction based on technology at the plant site within the set of plants whose primary mission is to provide access to local markets. The Ferdows (1989) distinction within this set is between those that have a high degree of technical activities at the site and those which do not.

H1a (and H1b) are phrased as alternative hypotheses to the Ferdows framework so rejecting these hypotheses is support for the Ferdows generic roles for international factories typology.

> H1a: Among plants for which access to markets is an important location factor, plants with a high degree of technology at the site use the same management systems as those with a low degree of technology at the site (Contributor vs. Server distinction).

Economists have long argued that firms would locate plants in order to gain access to inexpensive inputs to production. The alternative hypothesis to Ferdows (1989) that is consistent with this view is that local technology is like other inputs and that there will be no difference between plants in terms of their management systems based on whether plants are located for Access to Local Technology.

> H1b: Among plants for which access to inputs is an important location factor, there is no difference in management systems between plants which are distinguished by the relative importance of Access to Low Cost Inputs versus Access to Local Technology (Source and Off-Shore versus Lead and Outpost distinction).

The above hypotheses jointly examine the issue of whether the typology proposed by Ferdows (1989) identifies significant differences between plants in terms of the management systems that are used in these plants. These hypotheses question whether there is a unique fit between types of manufacturing mission and management systems. If there is a match between plant role and management systems, one would also like to know whether the fit is the same as that proposed by Ferdows (1989) for particular plant roles. The following sections investigate this question.

Centralization/Decentralization in a Multinational Network. For all plants in a network we expect headquarters to retain control over dimensions such as *human resource policies for management, long range production planning, and quality standards.* The logic is that the headquarters has to control the *human resource policies for management* because these managers belong to a 'central pool'. It can decentralize how to manage the local labor, or *human resource policies for labor*, because that is a local skill issue. But the *human resource policies for management* are an important control lever that the headquarters would want to keep. *Long range production planning* is essentially the same as capacity planning, and that has to be done on a global basis if this is to be a network rather than a 'multidomestic' collection of plants each serving a local market independently of the network (Barlett and Ghoshal, 1989).

Descriptively, we would expect that the degree of autonomy for *human resource policies for management*, *long range production planning*, and *quality standards* would be lower than for other management systems, such *as production scheduling, raw material sourcing, component sourcing, equipment sourcing*, and *labor human resouce policies.*

Centralization/Decentralization Differences Between Types of Plants- Vertical Contrasts in the Ferdows Framework Based on Management Depth. Since we think that headquarters will retain control over *long range production planning* and *human resource policies for management* we do not expect differences in autonomy on these variables between plant types. Here we consider differences in centralization/decentralization of activities in the plant network based on degree of management depth at the plant site that would tend to be associated with differences due to the degree of technical activities. In a later section, we examine vertical differences based on the management of technical activities at the plant site.

Both Off-Shore and Server plants have managers in place who are responsible for day to day production decisions. However, the scope of these decisions differs in each. In Off-Shore plants, most production decisions are linked tightly to headquarters, particularly those related to *production schedules* since these decisions are interdependent with other plants. The example of the Maquiladora plants in Mexico, which take advantage of low local wages and then export product back to plants in the U.S., are used to illustrate this type of plant (Ferdows, 1989). Since low cost local wages was an important reason to locate the plant to serve the rest of the network of plants, it is likely that the headquarters will also retain some responsibility for the form of *human resource policies for labor* rather than delegate them entirely to the plant. In this case, the contrast in managerial systems that support production systems is quite clear and the control by headquarters over such things as *production schedules* and *human resource policies for labor* can be understood.

> H2a: Source plants will differ from Off-Shore plants in their greater control over production related decisions such as *production schedules*, and *human resource policies for labor.*

In Server plants however, production scheduling decisions are made primarily for the needs of local customers and thus are not controlled by headquarters. The Server plants are independent production platforms; soft-drink bottling plants are considered a good example of Server plants. The managerial investment necessary for new product or process development will be greater in Contributor than in Server plants and this could have implications for production scheduling over new products. Thus, while we still expect greater autonomy over *production scheduling* in Contributor plants than in Server plants due to their managment depth, we do not expect this difference to be as great as the difference between Source and Off-Shore plants. *Human resource policies for labor* can be an important extension of the brand image of a company, particularly in distribution intensive industries which might be likely to utilize Server plants. Therefore we do not think that *human resource policies for labor* would be delegated entirely to Server plants and that due to the greater management depth in Contributor plants, there would be more autonomy at these plants over *human resource policies for labor.*

H2b: Contributor plants will differ from Server plants in their greater control over decisions such as *production schedules*, and *human resource policies for labor*.

Lead plants and Outpost plants are also located for purposes of access to an input but the input is local technology rather than other low cost inputs. In this regard, we consider the Lead plants to have greater management depth than Outpost plants and to have a very similar contrast to the contrast between Source and Off-Shore plants.

H2c: Lead plants will differ from Outpost plants in their greater control over production related decisions such as *production schedules*, and *human resource policies for labor*.

Responsibility for Coordination in the Plant-Business Unit Relationship - Horizontal Contrasts in the Ferdows Framework. Given a common degree of technical activity at the plant site, what are the differences in autonomy between plants that are located for Access to Markets versus those that are located for Access to Inputs? The primary contrast between Off-Shore and Server plants and between Source and Contributor plants involves the management of material flows into and out of the plants, and the autonomy that comes with responsibility for serving a market. Production schedules need to be integrated with other plants for both Off-Shore and Source plants and so these plants will be less responsible for production schedules than plants with similar levels of Technical Activities at the Site but are serving local markets. Nonetheless, since the primary task of Server and Off-Shore plants is their role as production platforms rather than product or process development, as in Contributor and Source plants, we would expect that the contrast in autonomy over production scheduling would be greatest in the bottom row of the Ferdows Framework, i.e. for Server plants compared to Off-Shore plants.

H3a: Server plants will differ from Off-Shore plants in their greater control over *production schedules* than Off-Shore plants.

H3b: Contributor plants will differ from Source plants in their greater control over *production schedules* than Source plants.

Off-Shore and Source plants are located to take advantage of unique access to inputs, and therefore we would expect these plants to be responsible for decisions regarding important inputs into production. When comparing each to its counterpart with a similar level of technical activities at the plant site, we would expect Off-Shore plants to have more control over inputs such as *raw material sourcing*, *component sourcing*, and *human resource policies for labor* than Server plants. In addition, we expect Source plants to have more control over inputs such as *raw material sourcing, component sourcing,* and *human resource policies for labor* than Contributor plants

H3c: Off-Shore plants will differ from Server plants in their greater control over *raw material sourcing, component sourcing*, and *human resource policies for labor.*

H3d: Source plants will differ from Contributor plants in their greater control over *raw material sourcing, component sourcing*, and *human resource policies for labor.*

Responsibility for Coordination in the Plant-Business Unit Relationship - Vertical Contrasts in the Ferdows Framework Based on Management of Technical Activities. According to Ferdows (1989), the Off-Shore factories are characterized by minimal management investment, no engineering work, day to day procurement, and management systems are designed solely for reporting to headquarters. The Off-Shore and Outpost factories are most similar to the Server factories in terms of their absence of this managerial investment in technical activities. In all three, managerial investment is kept solely at the level needed for day-to-day management of the plant.

In contrast, production decisions concerning *raw material sourcing, component sourcing*, and *equipment sourcing* might require the ability to make changes in processes or products at the plant. Thus autonomy for these decisions would probably be greatest in plants that have technical activities at the plant site. Global (as opposed to multidomestic) companies increasingly want to have global quality standards to support a global brand image and a global corporate image. The autonomy and responsibility for setting those standards would also probably be greatest in plants with technical activities at the site.

We will compare Source versus. Off-Shore, and Contributor versus Server, and Lead versus Outpost on the following four dimensions: *raw material sourcing, component sourcing, equipment sourcing* and *quality standards*. All four dimensions are related to technical activities in the sense in that one needs technical activities on site in order to be able to responsibly exercise autonomy. Therefore, we expect Source, Contributor and Lead plants to enjoy more autonomy on these dimensions.

> H4a: Source plants will differ from Off-Shore plants, in their greater emphasis on management systems that support responsibility and autonomy over technical decisions. These include systems such as *raw material sourcing*, *component sourcing*, *equipment sourcing*, and *quality standards*.
>
> H4b: Contributor plants will differ from Server plants, in their greater emphasis on management systems that support responsibility and autonomy beyond day-to-day production decisions. These include systems such as *raw materials, component sourcing*, *equipment sourcing*, and *quality standards*.
>
> H4c: Lead plants will differ from Outpost plants, in their greater emphasis on management systems that support responsibility and autonomy beyond day-to-day production decisions. These include systems such as *raw materials, component sourcing*, *equipment sourcing*, and *quality standards*.

While not explicitly a "vertical" comparison in the Ferdows framework, the framework does consider Lead plants to have a higher degree of technical activities at the site than Contributor and Source plants (Ferdows, 1989:Figure 2). Lead factories may be the sole producer of key products of components for the business unit or may initiate new technologies that are not dependent on interactions with suppliers or customers but may be more dependent on interaction with the business unit R&D headquarters. Production is in some sense subordinate to innovation in Lead plants, and innovation may be in part controlled by headquarters personnel. Still, the Lead plant will have the most managerial autonomy on technical decisions that relate to the ability to develop and produce new products and processes. While we compare Lead plants to Source and Contributor plants, this comparison is similar to a vertical comparison in that the difference between Lead plants and these plants is that Lead plants have even greater control and autonomy with regard to technical activities.

> H5: Lead plants will differ from Source and from Contributor plants in their greater control over *raw material sourcing*, *equipment sourcing*, *component sourcing* and *quality standards.*

Methods

Model Specification

Our sample consists of 157 manufacturing plants from multinational firms operating throughout the world. Out of 209 plants we are able to identify 157 plants that are distributed into all six of the strategic role categories of Ferdows (1989): i) Source (22), ii) Off-Shore (8), iii) Lead (40), iv) Outpost (3), v) Contributor (61) and vi) Server (23). We want to determine if there are differences in means by plant type with respect to responsibility for the coordination of management systems.

If many different variables are correlated with one another then even though there are differences in the means of management system variables, there may not be sufficient differences between these variables as a group to still think of the two types of plants as requiring "different" management systems on all these dimensions. We therefore use a multinomial logit analysis to test for these differences in management systems between plants with different roles. The multinomial logit model estimates whether the group of variables measuring particular management systems uniquely determine the type of plant. In addition, the logit model tests for consistency of results with the differences in means analysis.

The dependent choice variable represents whether the plant is a Source, Lead, Server, or Contributor plant. There are insufficient cases of Outpost and Off-Shore plants in our data set to include these plant roles in the logit model. We consider the plant-business unit coordination relationship in order to determine the types of management systems that are consistent with each plant strategic role. By plant - business unit coordination relationship we are concerned with the level of responsibility for coordinating production and technical decisions affecting the plant facility.

Plant Strategic Role = f (plant-business unit coordination relationship)

The model takes the form:

$$\text{Prob}\left[y_i = j\right] = \frac{\exp\left(\beta\, x_i\right)}{1+\exp\left(\beta\, x_i\right)} \qquad \text{for } j=0,1,2,3$$

where: y_i = the strategic role for plant i

x_i = a vector of management systems characteristics of the plant - business unit

β = a vector of estimated parameters.

The explanatory variables vary by observation (plant) and are constant across choices (strategies), therefore, the form of the model requires that it be estimated relative to a normalizing alternative, that is, for one choice, the β coefficient vector is set equal to zero. Since there are four choices, (the Outpost and Off-Shore choices must be dropped due to insufficient observations) the model must be estimated three times to obtain all pair-wise comparisons of interest. In the Contributor relative to Server case for example, each estimated β parameter represents the effect of the corresponding explanatory variable on the probability of the plant strategic role being a Contributor relative to it being Server.

Joint Test of Hypotheses 1a and 1b. We use a nested test of multinomial logit models to test Hypotheses 1a and 1b. These hypotheses examine whether the Ferdows (1989) typology adds significantly to our understanding of the need to differentiate management systems by plant types. We are essentially comparing a model with two choices to a model with four choices. Our sample only allows us to consider four of the six generic roles of plants in an international network: Source, Contributor, Server and Lead factories.

Fortunately, we can still test the distinctions made by Ferdows (1989). In the two-choice model, plants are differentiated only by the relative importance of Access to Inputs versus Proximity to Markets as the Primary Strategic Reasons for the Site. In the four-choice model, Access to Local Technology is added as a third category. A second dimension is also added based on the Extent of Technical Activities at the Plant Site. We use a joint test of Hypotheses 1a and 1b since Ferdows' uses both distinctions simultaneously in the framework.

We developed a method for a comparison of the explanatory power of the four-choice model (Source, Lead, Contributor, Server) that corresponds to the technology distinctions made by Ferdows, to a simpler two-choice model (Source and Lead, Contributor and Server). A log likelihood test is appropriate; however, to use this test, the logit models must be nested (Ben-Akiva and Lerman, 1985). One can not estimate two-choice and four-choice models separately and compare their log likelihood statistics. To create the required nesting, the two-choice model must be represented as a constrained four-choice model (Greene, 1986). That is, the Source and

Lead alternatives are constrained to have the same coefficients and the Contributor and Server alternatives are constrained to have the same coefficients. Furthermore, these coefficients must be the same as those estimated in the two choice model. The resulting log likelihood value is then compared to that of the freely estimated (unconstrained) four-choice model using a log likelihood test. This tests Hypotheses 1a and 1b jointly.

Data and Sample Description

The data used in this analysis is from the Global Manufacturing Network Survey conducted by Professors Brian Talbot and Aneel Karnani of the Graduate School of Business Administration at the University of Michigan. The purpose of this survey was to assemble a comprehensive database containing a variety of data regarding the configuration and operation of international manufacturing plant networks. The survey was administered in 1991 to plant managers in many countries representing 73 companies whose headquarters are located primarily in the U.S., Europe, and Japan. The plants they manage tend to be plants of large multinational firms that have been engaged in international manufacturing for a long time. All firms involved in the survey had sent managers to the Global Leadership Executive Management Program at University of Michigan, and thereby demonstrated an interest in and concern for education on management of international manufacturing enterprises. The response rate was exceptionally high (above 90%) for this reason.

Variables

Plants were classified into the 6 categories defined by Ferdows (1989) in terms of the primary strategic reason for the site and technical activities at the site. The items used to classify different plant roles can be seen in Table 2 and the explanation for how these items are used is explained in Appendix 1.

Insert Table 2 about here

Explanatory variables in the model include measures of the types of management systems for coordination of materials, production and technical decisions between the plant and other parts of the company. On each type of decision the question is "Who has the primary responsibility for the following tasks for your plant?". There is a 5 point scale in which "your plant" is 5, "your plant in coordination with another plant" is 4, "another plant" is 3, "regional headquarters" is 2, "worldwide headquarters" is 1, and "don't know/not sure" is 0. The decisions considered are the following: *long range production plans*, *production schedules*, *raw material sourcing*, *component sourcing*, *equipment sourcing*, *quality standards*, *human resource policies for management*, and *human resource policies for labor*.

Empirical Findings

There is broad support for the Ferdows (1989) framework in our joint test of H1a and H1b. The alternative hypotheses to the Ferdows' framework are rejected (Table 3). Clearly, the novel distinctions in the framework pertaining to technology are important for understanding the differentiation of management systems within plants. More specifically, for plants that consider access to markets an important location factor, the distinction between whether there are technological activities at the plant is <u>not</u> unimportant for understanding their management systems.

For H1b, among those plants for which access to inputs is an important factor, the distinction between technological inputs and other inputs is not unimportant for understanding management systems at the plant. The nested log likelihood test of whether these distinctions should be made indicates that the two choice model of distinguishing only on the basis of markets and inputs is not significantly different than the null hypothesis which is making no distinction at all.

The four choice model which tests whether one should make the distinction between Source and Lead plants (H1a) and between Contributor and Server plants (H1b) clearly indicates that this model fits better than the model in which these distinctions are not made (significant at 95% confidence level). We conclude from this test that one should use the four-choice model. This supports the use of the two technology related dimensions which Ferdows (1989) used. Next we consider the more specific hypotheses related to "fit" of management systems to particular plant roles.

Insert Table 3 about here

Centralization/Decentralization: Descriptive Findings. In Table 4 the first 8 rows relate to management systems, and the numbers represent the degree of autonomy (or decentralization) that the plants enjoy on that particular dimension. The first column is the degree of decentralization on each dimension in the entire sample of plants (in multinational manufacturing companies). We expected *human resource policies for management*, *long range production planning*, and *quality standards* to be the least centralized (smallest numbers), and that is, in fact, empirically true! Headquarters has to control the *human resource policies for* *management* because these managers belong to a 'central pool' and are a control lever that it needs to retain. In addition, headquarters retains control over *long range production* on a global basis. This allows headquarters to manage its plants as a network rather than as a 'multidomestic' colection of plants each serving a local market independently. Finally, global (as opposed to multidomestic) companies increasingly want to have global quality standards to support a global brand image and a global corporate image and there is a high degree of control retained by headquarters for *quality standards.* Similarly, we expected *production scheduling* and *human resource policies for labor* to be very decentralized -- and they are.

If one takes an average of the eight rows in Table 4, that can be considered to be an index of the overall autonomy of a plant, or Index of Autonomy, which is the last row. For reasons of both management depth and the availability of technical activities, we would expect Source plants to be more autonomous than Off-Shore plants, and they are: 3.81 vs. 3.25. Similarly, we would expect Contributor plants to be more autonomous than Server plants, and they are: 3.60 vs. 3.39. Similarly, we would expect Lead plants to be more autonomous than Outpost plants, and they are: 3.4 vs 3.08. Though the differences in means support the idea of greater autonomy in the plants above the vertical in the Ferdows' framework, these differences are not statistically significant at the 90% confidence level.

Centralization/Decentralization Differences Between Types of Plants- Vertical Contrasts in the Ferdows Framework Based on Management Depth. We expected Source plants to have greater control over *production scheduling* and *human resource policies for labor* than Off-Shore plants due to their greater management depth. There is support for H2a that Source plants will have greater control over *production scheduling* than Off-Shore plants (Table 5). Source plants take more control over *production scheduling* than the Off-Shore plants. This is consistent with the relative absence of administrative control at Off-Shore plants when compared to Source plants and the importance of supply integration of Off-Shore plants with other plants. Autonomy for *production scheduling* is also greater for Contributor than for Server plants and Lead plants than for Outpost plants but these differences are not significant. The problem may be that *production scheduling* is so decentralized to begin with in the entire sample (values are at 4.00 or above for all types of plants in Table 4) that the empirical results cannot detect subtle differences between types of plants.

As expected, there is more control over *human resource policies for labor* in Source plants than in Off-Shore plants but this finding is not significant. This is also true for Contributor plants compared to Server plants (Table 5) and for Lead plants compared to Outpost plants (Table 4). This could be because all plants must control some elements of their *human resource policies for labor* and would thus have some autonomy over this decision. The prevalent decentralization of some part of this decision could make distinctions about the degree of central control by headquarters hard to identify with statistical significance.

Responsibility for Coordination in the Plant-Business Unit Relationship - Horizontal Contrasts in the Ferdows Framework. As expected in H3a, there is greater control over *production scheduling* in Server plants than in Off-Shore plants, but this difference is not significant. Server plants have more autonomy with respect to their output decisions since they are serving their own market rather than other plants in a network. Again, the difference is in the direction expected but the insignificant findings could be due to the predominantly decentralized decisions concerning production scheduling.

Contrary to our expectations in H3b, Contributor plants have less control over *production scheduling* than Source plants but this relationship is not significant. The additional responsibilities of Contributor plants beyond production could moderate the autonomy of *production scheduling* in this type of plant and may be related to the somewhat lower degree of autonomy at Contributor plants than at Source plants.

We expected the plants with more control over inputs would have greater autonomy with respect to *raw material sourcing, component sourcing,* and *human resource policies for labor.* There are no significant differences in the means between Off-Shore plants and Server plants, though, as expected, there is more autonomy over *raw material sourcing* and *component sourcing* in Off-Shore plants than in Server plants (H3c). Despite this support for H3c there is also counter evidence that there is more control over *human resource policies for labor* in Server plants (H3c). It is possible that *raw material sourcing* and *component sourcing* are more unique input problems for Off-Shore plants, while *human resource policies for labor* can have important implications for serving a market, particularly if there is a service dimension to the manufacturing industry such as distribution.

While not significant, there is higher autonomy for key input decisions in Source plants than in Contributor plants as expected. There is more plant level control over *raw material sourcing*, *component sourcing* and *human resource policies for labor* in Source plants than in Contributor plants, though the difference is essentially zero for *human resource policies for labor*.

Responsibility for Coordination in the Plant-Business Unit Relationship - Vertical Contrasts in the Ferdows Framework Based on Management of Technical Activities. In H4, we expected greater autonomy for plants in the upper row of the Ferdows Framework with regard to management decisions involving technical expertise, such as *raw material sourcing, component sourcing, equipment sourcing*, and *quality standards*. For Source plants compared to Off-Shore plants (H4a), there is greater autonomy at Source plants for all four technically related managerial decisions. Only *quality standards* has a marginally significant difference in the greater autonomy for Source plants (Table 5).

In H4b, we also expected Contributor plants to have greater autonomy than Server plants with regard to technical decisions. Again, in all four of these decisions there is considerably more autonomy for the plant in the top row of the framework, the Contributor plant. We find significant evidence to support this hypothesis that Contributor plants are more likely to be responsible for *component sourcing* and for *quality standards* than are Server plants. There is support here in both differences in means by plant type and in the logit model contrasts (Tables 4, 5 and 6). (The logit model contrast is not available for Source vs. Off-Shore). This finding that there are differences in management systems for plants with different levels of technology at the site is fairly robust and indicative of the management challenges at these different types of plants.

There is greater autonomy for Lead plants compared to Outpost plants with regard to *raw material sourcing* and *equipment sourcing* (H4c), however their is less autonomy with regard to *equipment sourcing* and *quality standards*. None of these differences are significant and due to the very small sample size for Outpost plants (3), these findings are highly unreliable.

Insert Table 4, 5, and 6 about here

We also expected that Lead plants would differ from Source and Contributor plants in their greater control over *raw material sourcing, equipment sourcing, component sourcing*, and *quality standards* (H5). We found that Lead plants were less autonomous on all of these dimensions than both Source and Contributor plants. We found significantly <u>less</u> control over *component sourcing* and *equipment sourcing* in Lead plants than in Contributor plants (Table 5). We also found significantly <u>less</u> control over *component sourcing* in Lead plants than in Source plants (Table 5). This suggests *equipment sourcing* and *component sourcing* decisions may be shared with R&D facilities for unique products made by Lead plants while the more standard equipment sourcing done by Contributor and Source plants may be delegated directly to those plants.

While this finding counters the idea of the Lead plant as a plant with "absolute" control over important long term production related decisions, it is also possible that this reflects an interdependence with business unit headquarters or other plants in terms of product and process development that is less present in Source and Contributor plants.

Conclusions and Limitations

We utilize the Ferdows (1989) typology and find it to be a useful device for organizing information about differences in management systems between plants with different roles in an international network. We have tested whether management systems are different for different plants in two ways. In hypothesis 1a and 2a we tried to reject the hypotheses that a simpler typology than the Ferdows typology would do just as well at differentiating management systems among plants. It was found that the distinctions based on technical activity at the plant, and the importance of local technology were important ones for understanding the different management systems used in international plants. This is a test which uses all of the management systems together to determine whether, as a group, plants with different roles are managed with sufficiently different systems that these systems could be used to differentiate between plant types. The answer is that they can. The second way we have tested for different management systems is to test more specific hypotheses about the "fit" of particular management systems to plant roles.

The framework is particularly successful in contrasting management systems for plants that are required to develop manufacturing capabilities involving technical expertise with those that are primarily production platforms. The control over *quality standards* and *component sourcing* at Contributor plants when compared to Server plants is indicative of the greater management responsibility taken by the management of plants that have greater technical activities at the plant location.

We expected production decisions involving technical choices to be controlled more by Lead plants than by Contributor or Source plants. But these decisions did not differ between the types of plants as we, and Ferdows, expected. While we were generally correct in expecting more control over these decisions for Contributor plants compared to Server plants, and Source plants compared to Off-Shore plants, we attributed too much control over these technical production decisions to Lead plants. We suspect that the autonomy over non-technical production decisions due to greater management depth, which was shown to be greater at Source plants than for example at Off-Shore plants, also carries over to some of these technical production decisions such *as raw material sourcing* and *component sourcing* when Source plants are compared to Lead plants. Similarly, when Lead plants are compared to Contributor plants the Contributor plants retain more autnonomy over *component sourcing* and *equipment sourcing*. Lead plants may be making decisions related to *raw material sourcing*, *equipment sourcing* and *component sourcing* in combination with business unit R&D while Contributor and Source plants are freed from this constraint.

Which management systems need to be differentiated if different plants are combined in the same plant network? Table 5 indicates that one could combine Contributor and Server plants in the same network if it is not costly to differentiate management systems on production decisions involving technical choices within the subsidiary such as *component sourcing* and *quality standards*. *Quality standards*, as well as *production sheduling* systems would have to be differentiated if Source and Off-Shore plants are combined. One might also think of the need to manage cooperation between these plants for such things as quality standards that are developed in Source and Contributor plants for use in Off-Shore and Server plants respectively.

There are few systems which must be differentiated when combining Contributor and Source or Server and Off-Shore plants. Likewise, Lead plants can be combined with Contributor or Source plants if it is not costly to allow for the reduced autonomy over technical decisions such as *component sourcing* and *equipment sourcing* in Lead plants. As stated earlier, it is likely that this requires explicit dependence on business unit R&D facilities in Lead plants which would not be as necessasary in Contributor and Source plants. What are the implications for headquarters -subsidiary relationships and the Integration/Responsiveness Grid (Prahalad and Doz, 1989)? Differentiated fit not only has implications for consistent management systems within the business unit but also has implications for the operations and management of plants within a network .

We have put the Ferdows (1989) generic roles for international factories through multiple screens. We have shown that it explains differences in management systems used in international plants better than a more naive model that doesn't make the distinctions based on technology that are put forth by Ferdows. We next examine the model to determine whether there is evidence for the particular characteristics of plant roles that he described. In many cases these characteristics are present though we have discussed some exceptions. In general however, there is strong evidence that management systems are different for different plant roles and that undifferentiated management systems at the business unit level for different plant will result in the inability for these plants to pursue their roles effectively.

Table 1

Generic Roles of International Factories (Ferdows, 1989)

		Primary Strategic Reason for the Site		
		Access to Low Cost Production Input Factors	Use of Local Technological Resources	Proximity to Market
Extent of Technical Activities at Site	High	Source	Lead	Contributor
	Low	Off-Shore	Outpost	Server

Table 2

Questions used to Identify Plants Within the Ferdows Framework for the Generic Roles of International Factories (Ferdows, 1989)

		Primary Strategic Reason for the Site		
		Access to Low Cost Production Input Factors	Use of Local Technological Resources	Proximity to Market
Extent of Technical Activities at site.	High	Source	Lead	Contributor
	Low	Off-Shore	Outpost	Server
original :		Access to:	Access to:	Proximity to:
product design		-low cost labor	-local technology	-important markets
process design		-raw materials	-skilled labor	-key customers
changes in:		-energy	-advanced infrastructure	
product design		-key suppliers		
process design				

Table 3

Joint Test of H1a and H1b

Logit Model	Model Statistics
4 - Choice (Source, Lead, Contributor & Server)	Log Likelihood ($\hat{\beta}$) = -173.62 Log Likelihood (0) = -189.17 X^2 (d.f. = 27-3 = 24) = 31.101 (p<.15)
2 - Choice (Source, Lead, Contributor & Server)	Log Likelihood ($\hat{\beta}$) = -97.18 Log Likelihood (0) = -99.54 X^2 (d.f. = 9-1 = 8) = 4.7144 (p>.25)
Nested Logit Test 4 - Choice Constrained Model (Source & Lead have some coefficients) (Contributor & Server have some coefficients) $X^2 = -2[-199.3046 - (-173.6182)] = 51.37$ (p<.005) (d.f. = 27-18=9)	Log Likelihood (β) = -173.62

Table 4

Management Systems Variable Means by Generic Roles of International Plant Types
Lower Numbers Mean Less Autonomy Over Decisions by the Plant

Management System Variables	Entire Sample n=157	Source n=22	Contributor n=61	Lead n=40	Off-Shore n=8	Outpost n=3	Server n=23
Long Range Production Planning	3.21	3.50	3.26	2.90	2.50	2.33	3.70
Production Scheduling	4.55	4.86	4.62	4.38	4.13	4.00	4.57
Raw Material Sourcing	3.52	3.86	3.57	3.30	3.75	2.67	3.43
Component Sourcing	3.69	4.14	3.93	3.38	3.75	2.67	3.26
Equipment Sourcing	4.13	4.27	4.33	3.83	3.63	5.00	4.04
Quality Standards	2.99	3.23	3.21	3.18	2.38	3.67	1.96
Human Resource Policies for Management	2.58	2.55	2.59	2.70	2.5	1.33	2.57
Human Resource Policies for Labor	3.80	4.05	4.03	3.58	3.38	3.00	3.61
Index of Autonomy (Mean of above)	3.56	3.81	3.69	3.41	3.25	3.08	3.39

Table 5

Differences of Means of Management Systems in Multinational Plant Types

(For A vs. B, Mean of A minus Mean of B)

Management System Determinants	Source vs. Off-Shore	Contrib-utor vs. Server	Lead vs. Source	Lead vs. Outpost	Lead vs. Contrib-utor	Contrib-utor vs. Source	Server vs. Off-Shore
Long Range Production Planning	1.00^	-0.43	-0.60	0.57	-0.36	-0.24	1.20*
Production Scheduling	0.74**	0.06	-0.49*	0.37	-0.25	-0.24	0.44
Raw Material Sourcing	0.11	0.14	-0.56^	0.63	-0.27	-0.29	-0.32
Component Sourcing	0.39	0.67*	-0.76*	0.72	-0.56*	-0.20	-0.49
Equipment Sourcing	0.65	0.29	-0.45	-1.17	-0.50*	0.06	0.42
Quality Standards	0.85^	1.26**	-0.05	-0.48	-0.04	-0.01	-0.42
Human Resource Policies for Management	0.05	0.03	0.16	1.37^	0.11	0.05	0.07
Human Resource Policies for Labor	0.67	0.43	-0.47	0.58	-0.46^	-0.01	0.23
Significance: *** > 99% ** > 95% * > 90% ^ > 80%	Tests Assume Pop. Variance Equal						

Table 6

Logit Model of Management Systems in Multinational Plant Types

Management System Determinants	Contributor vs. Server	Lead vs. Source	Lead vs. Contributor	Contributor vs.Source
Constant	-1.05	4.29*	1.40	2.89
Long Range Production Planning	-0.42**	-0.09	-0.02	0.08
Production Scheduling	0.13	-0.52	-0.08	-0.44
Raw Material Sourcing	-0.37^	0.01	0.15	-0.14
Component Sourcing	0.45**	-0.23	-0.23^	0.00
Equipment Sourcing	0.19	-0.05	-0.23	0.18
Quality Standards	0.49***	0.05	0.05	0.01
Human Resource Policies for Management	-0.13	0.24	0.20^	0.04
Human Resource Policies for Labor	0.24	-0.19	-0.22^	0.03
T-stat *** >2.58 for 99% ** >1.96 for 95% * >1.65 for 90% ^ > 1.28 for 80%	Log Likelihood n=146 -173.62 Log Likelihood (0) -189.17 Chi-Squared (24) 31.10, signif. at 85%.			

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Appendix 1

Classification Scheme Used for Classifying Plants Into Discrete Strategic Roles

For classifying plants into discrete plant roles we used responses to the question: "To What degree did the following factors influence your plant's location decision?" Plants that had a high value on "access to raw materials", "access to low-cost labor", or "access to energy" or "access to key suppliers" were deemed to have Access to Low Cost Production Input Factors as their primary strategic mission. Likewise, plants with a high value on "access to local technology", "access to skilled labor" or "access to advanced infrastructure" were considered to have Use of Local Technological Resources as their primary strategic mission. Finally plants that said "proximity to important markets", or "proximity to key customers" were considered to have "proximity to market" as their key strategic reason for the site. Responses to these questions were compared in terms of the highest score for any item in a group. Ties were settled by comparing the average score for the items in each group (See Table 2).

To determine the Extent of Technical Activities at the Site , responses to the following questions were used. The question was, "Who has the primary responsibility for the following tasks for your plant?" Possible answers included "your plant", "your plant in combination with another plant", "another plant", "regional headquarters", "worldwide headquarters" and "don't know/ not sure". Answers which were either "your plant" or "your plant in coordination with another plant" were given a "1". Others were given "0". The four items that were considered were "original product design, "product design changes", "original process design" and "process design changes". If "1", then the plant was considered to have a high level of Technical Activities at the Site (See Table 2).

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